Appendix I. Literature summary

Literature Summary: Bull Trout Habitat Requirements and Observations in the Jarbidge Basin

SUBSTRATE FINE SEDIMENT: High levels of fine sediment can reduce bull trout embryo survival by: 1) decreasing gravel permeability (therefore availabilty of DO), 2) slowing rate of metabolic waste flushing, and 3) interfering with emergence by filling interstitial space through which the fry emerge (Weaver and Fraley 1991).

Bull trout embryo survival correlates to percentage of fines (<6.4 mm) in streambed. Survival unaffected up to 30% -- dropped off sharply at 30% fines --at 40% fines survival fell below 20% (Shepard et al. 1984).
Average survival to emergence in Coal Creek fell from over 60% in gravels with 30% fines to 0% with 44% fines (Weaver and White 1985).

Successful incubation is more strongly related to intergravel DO than percentage of fine sediment in natural situations. Artificial incubation cells do not allow gravel composition to affect permeability (Weaver and Fraley 1991 op cit).

Bull trout more tolerant of fines than cutthroat, steelhead and brook trout as reported in literature, their tolerance is similar to that of chinook salmon   (Tapple and Bjornn 1983, and Hausle and Coble 1976).

Weaver and White (1985) found number of fertilized eggs hatching (in gravel) in lab with 20, 30, and 40% material <= to 9.5 mm was 40, 20, and 1%, respectively. But, lab survival was lower than what found in field.   Shepard et al. (1984) regressed a substrate score vs the number of bull trout greater or equal to 75mm in each 100 square meters of stream.

Shepard et al.(op. cit.) displayed a graph relating percent survival of bull trout embryos through emergence to percent fines < 6.4mm. The relation was Y=-5.13X + 225.2; r^2=.876, and P=0.0001.

Sediment increases attributed to road development was correlated with substrate score, percent of stream bed < 6.4mm, and % of stream < 2mm. No other stream variables tested were significantly related to streambed condition nor was the sediment yield from clearcutting a significant variable in any of the regressions (Shepard et al. op. cit.).

Interior Columbia Basin - Summary of Scientific Findings: (page106), the amount of fine sediment (sediment less than 6mm) on channel beds was negatively influenced by road density.

TEMPERATURE
Coal Creek incubation period (fertilization to emergence) was 223 days, 634 TU; fertilization to hatch was 350 TU (Weaver and White 1985).

Incubation temperature influences size at hatch and duration of hatch. Largest alevins are produced at the lowest temperatures (2.0 and 4.0 C). Temperatures >8.0 C increase rate of yolk absorption and decrease fry size (McPhail and Murray 1979).

Total incubation time decreases as temperature increases but hatch duration does not. Shortest hatching duration was at 4.0 C (McPhail and Murray op. cit.).

Mortality was highest at 8.0-10.0 C, and lowest at 2.0-4.0 C (McPhail and Murray op. cit.).
Temperature related mortality occurred at two developmental stages: closure of blastopore (at low temperatures <6.0 C) and hatching (at high temperatures >8.0 C) (McPhail and Murray op. cit.).

Bull trout usually spawn in September and October (Fraley and Shepard 1989; Shepard et al. 1984).
Spawning might begin as early as August in a tributary to Bumping Reservoir in the upper Yakima River (>3,500 ft elevation; Brown 1992).

Ratliff (1992) observed spawning the first week of August in a tributary of the Metolius River in Oregon.
In Mackenzie Creek, tributary to Arrow Lake, British Columbia, spawning behavior began the first week in September when water temperatures were near 9C. Actual spawning began September 14 -- the first day water temperatures dropped below 9C. Spawning continued from mid-September to the end of October (McPhail and Murray 1979).

From Rode's (1988) literature review; bull trout are repeat spawners, but they miss some years. Spawning starts as max daily T falls below 9C, they spawn between 5C and 9C, generally in September-October.

Bull trout seem to prefer cold water. In summer, 15C seems to be the upper for bull trout habitat. Spawning and rearing occur in streams that do not exceed 15C.

Temperatures in excess of 15 C limit bull trout distribution (Allan 1980, Brown 1992, Fraley and Shepard 1989, Goetz 1991, Oliver 1979, Pratt 1985, Ratliff 1992, Shepard and others 1984b).

COVER
Both adults and young seem to desire cover. When it is removed the carrying capacity is lowered.
Adults hold under cover (Shepard et al. 1984), in plunge pools, or near cutbanks (McPhail and Murray 1979).

Fluvial populations of adults winter in deep pools or move downstream to large water (Allan 1980).

Adults in deep pools often are associated with large concentrations of mountain whitefish (Carl 1985).
Once in the tributary, adults have been observed in shallow runs, under log jams or in deep pools (Shepard et al. 1984).

Juvenile cutthroat are found throughout water column, particularly in pools -- juvenile bull trout found along stream bottom, closely associated with instreamcover (Pratt 1984).

Interior Columbia Basin - Summary of Scientific Findings: (page106), Pool frequency (large pools and all pools) was inversely correlated with road density and management intensity.

CHANNEL STABILITY

Highly variable streamflows and unstable channels negatively influence the survival of bull trout (Goetz 1989, and Weaver 1985). Embryos in the gravel are particularly vulnerable to early spring, and mid-winter flooding and scour events (Elwood and Waters 1969, Seegrist and Gard 19720).

High bedload movement and low channel stability were associated with low bull trout numbers in the Coeur d?Alene River drainage (Cross 1992).

Channel stability is indexed by width-to-depth ratio, maximum width-to-depth ratio, and pool frequency (Overton and others 1996).

Migration corridors (nodal habitat)

Bull trout need migration corridors to tie safe wintering areas to summering or foraging areas. Movement is important to the persistence and interaction of subpopulations within the larger metapopulation. Gene flow, refounding of locally extinct populations, and support of locally weak populaitons require open corridors among populations. Migratory populations are likely to stray more between streams than resident populations, increasing the potential for such dispersal. Disruption of migratory corridors will increase stress, reduce growth and survival, and possibly cause loss of migratory life history types. Resident stocks live upstream from both natural and an increasing number of man-caused barriers. These stocks are sometimes isolated in marginal or more extreme habitats, however, and will be at increased risk of extinction (Horowitz 1978).

In Rapid River, ID, fluvial bull trout migration began in late May and peaked by early-to-mid June. Movement typically is complete by late August. Historically, runs have started as early as April 15 and ended as late as September 7th (Schill 1992). Adults migrate primarily during the night in Flathead R. (Shepard et al. 1984). Pairing may have occurred at the mouth of tributary streams. Bull trout commonly moved as pairs (Shepard et al. op. cit.). Migration upstream occurred from dusk to midnight and there was evidence that the fish traveled in pairs (McPhail and Murray 1979). Bull trout have strong homing instinct, returning to specific spawning grounds each year (Fraley et al. 1981).

Substrate as cover:
Juveniles were most often found closely associated with instream cover in the form of streambed material (cobble and boulders) and submerged fine debris (Shepard et al. 1984). Small bull trout were frequently seen over silt and sand substrate accumulated behind water velocity obstructions used as cover (Shepard et al. op. cit.). Juveniles used rubble and boulder substrate cover in Trapper Creek (Goetz 1989).

Nightime vs daytime activity
On the Deschutes National Forest, population estimates from nighttime snorkeling were 1.5 to 6 times higher than the daytime estimates (although sample sizes were smaller) in areas where divers were unable to observe juveniles using interstitial spaces as daytime cover (Goetz op. cit.).

Side channels
Side channels may act as refuges from current and predation for bull trout fry. Estimates of 0+ bull trout in side-channels were 0.39 fish/m2, while main channel estimates were only 0.065 fish/m2. Estimates of 2+ fish were 0.002 fish/m2 in side channels and 0.02 fish/m2 in the main channel. Side channels were less than 15 cm deep and had no cover for larger fish. (Goetz op. cit.).

Juvenil bull trout micro-habitats:
During the summer, over 65% of juvenile bull trout used some type of woody debris for cover during the day--33% used fine woody debris and 25% used course woody debris (Goetz 1989). On Jack Creek (Deschutes National Forest), coarse woody debris and fine woody debris were each used by approximately 40 percent of the juveniles during the summer (Goetz op. cit.). In the winter 50% of juveniles used undercut banks for cover during the day. Spring cover preferences for juveniles were large woody debris and coarse woody debris (57%), fine woody debris (28%), and undercut banks (14%). Sample sizes in the winter were small (Goetz op. cit.). Age 1 and older bull trout closely associated with cover in North and Middle Fork tributaries. Canopy, instream cover and percent of class 1 pools best explained variations in juvenile bull trout densities ($r = 0.472$, $p < 0.05$) (Fraley and Graham 1981).

Habitat complexity
Gorman and Karr (1978) found fish species diversity to be correlated with stream habitat complexity as estimated by stream depth, bottom type, and current Small bull trout were found just above, in contact with, or in the streambed (mean distance above streambed 0.03 m) where velocities were low (average 0.09 m/s) (Shepard et al. 1984). Bull trout were usually in pockets of slow water close to the stream bed and associated with water velocities of 0.10-0.12 m/s created by obstructions (Pratt 1984). YOY bull trout used low velocity backwaters and side-channels (McPhail and Murray 1979). Average focal elevation was < 10 cm during the day in any season. At night, most fish observed were resting completely on the bottom at 0.0 cm (Goetz 1989). Bull trout <100 mm were 0.03 mean distance from streambed. Bull trout > 100 mm used faster water (to 0.12 mps), were located higher in the water column (0.08 m above streambed), and in deeper water

(0.45 mean depth) (Shepard et al. 1984 op. cit.). Juveniles (1+ and 2+) are found mainly in pools and to a lesser degree in runs.

Spawning

The majority of bull trout spawning occurred in large tributaries or in the lower reaches of small tributaries (Shepard et al. 1984). Initiation of spawning is related to temperature (<9 C), photoperiod and streamflow (Shepard et al. op. cit.). McPhail and Murray (1979) reported 9 C as threshold temperature to initiate spawning. Areas of concentrated bull trout spawning were associated with ground water recharge (Graham et al. 1981). Adult bull trout selected areas directly influenced by groundwater recharge, low gradient at interface between high gradient and low gradient portions of a stream, and where the stream split into multiple channels (Shepard et al. op.cit.).

Water velocities in spawning habitats ranged between 0.24 and 0.61 m/s at front edge of redd depressions (Shepard et al. 1984). Water velocities in redd sites 0.57 to 0.64 m/s at 1.0 cm above gravel (McPhail and Murray 1979). Runs or tails of pools with water were 0.2 to 0.8 m deep (Shepard et al. op. cit.). Bull trout often spawned immediately downstream from low gradient-high gradient interfaces. Concentrations of redds in the upstream portion of low gradient reaches (Graham et al. 1981). Low gradient <1% seemed to be preferred for spawning (McPhail and Murray 1979 op. cit.). Anadromous Dolly Varden in northern Alaska selected areas in main channels with fairly strong current at depths of 0.2 m or more, or in springs (Yoshihara 1973 cited by Armstrong and Morrow 1980).

Overhanging cover was positively correlated to spawning use. Bull trout not actively engaged in spawning were observed closely associated with undercut banks, debris jams, or deep pools (Graham et al. 1981). Bull trout spawning areas were associated with shade from overhanging terrestial vegetation and in close proximity to pools or cutbanks (McPhail and Murray 1979). Spawning areas have escape cover nearby average distance between redd and stream bank was 3m (Rode 1988). Stream order, D-90, and channel gradient were most significant variables affecting spawning bed distribution. Overhanging bank cover and percent gravel and cobble were also significant though neither was significant in simple correlation analysis. The combination of stream order and diameter of substrate material that was larger than 90 percent of all stream bed material was the best variable combination (Graham et al. op. cit.).

In September, 2001 Burton, Klott, and Zoelick (2001) conducted spawning and substrate surveys on Dave Creek to assess grazing influences on bull trout spawning success. The spawning survey was conducted along the entire length of Dave Creek from the road crossing in Section 24 upstream to about 200 meters south of the National Forest Boundary in Section 6. They observed bull trout actively spawning throughout this reach of stream, and suspected that bull trout also spawn downstream into Section 13. Bull trout spawners averaged approximately 250 millimeters in length, and ranged in size from 200 to 350 millimeters. They conducted habitat assessments at the National Forest Boundary and downstream on public lands at the confluence of Dave Creek and Little Island Tributary (Morgan Draw). In the downstream assessment on Public Lands, they observed highly complex stream habitats with dense overstory cover, frequent pools, much in-channel cover, and high levels of fine sediment embedded in the substrate. The stream channel was about 2-3 meters in width at that location. They found that substrate fines increased downstream of the Little Island Tributary, although the increase was not statistically significantly. This investigation revealed that elevated sediment levels in Dave Creek (40% fines in pools and 60% embeddedness on spawning habitats) likely originate from erosion of the degraded channel upstream in sections 13, 24, 25, and 36. Substrate samples taken in Section 6, upstream of the Forest Boundary showed a marked decrease of both % fines and embeddedness (4% fines in pools and <5% embeddedness in spawning habitats). They estimated, that with degraded substrates, Dave Creek could produce about 4 times as many bull trout. This would require modifications of livestock grazing intensity in the degraded stream reaches of upper Dave Creek, mostly on private lands.

Conservation:

General requirements for conserving species such as bull trout have been known for many decades. For example, Rich (1939) wrote, "Given a species that is broken up into a number of such isolated groups or populations, it is obvious that the conservation of the species as a whole resolves into the conservation of every one of the component groups; that the success of efforts to conserve the species will depend, not only upon the results attained with any one population, but upon the fraction of the total number of individuals in the species that is contained within the populations affected by the conservation measures."

Jim Bob Pipeline Diversion

Klott and Burton (2002) analyzed the potential affects of the Jim Bob pipeline diversion on Bull Trout. Jim Bob Creek is tributary to Robinson Creek which flows into the EF Jarbidge River in Nevada. Bull trout have been documented in the Headwaters of the EF Jarbidge, but none have been found in Jim Bob Creek. Bull trout migrants tend to wander and some may rear in Robinson Creek, although none have been seen there during fish surveys. The maximum amount of water that can be diverted by the pipeline is .8 cfs (360 gpm). The actual flow is less and varies with the time of year depending upon the flow of Jim Bob Creek. On September 24, 2002 a two gallon bucket was used to estimate water flow into the collecting vault for the Jim Bob Pipeline. Flow was determined to be approximately 70-80 gallons per minute (gpm) or 0.16 to 0.18 cfs. The dam on Jim Bob Creek dries up the creek immediately below the diversion, however, water begins flowing into the creek within 50 feet below the diversion point and flows increase further down stream.

On September 24, 2002 water width, depth and velocity data were collected above the water diversion, near the confluence of Jim Bob Creek and Robinson Creek and on Robinson Creek just upstream of the Jim Bob confluence to determine water flows. Channel width (wetted edge) was measured to the to the nearest 0.05 meters and water depths to the nearest cm were recorded at 0.10 m intervals. Water velocity was determined by dropping a twig in the water and recording the time (# of seconds) to cover a set distance (4 ft). Fall was selected to because stream flows are low and bull trout spawn in the fall. Tables 2, 3 & 4 contain the channel measurements taken for the respective stream segments.

Table 2. Channel measurements on Jim Bob Creek upstream of the diversion structure.										
Velocity =0.75 ft/sec	Channel Width (wetted edge) in meters (Sept-24-2002)									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Depth (cm)	1	3	5	2	5	6	8	5	3	0

Table 3. Channel measurements on Jim Bob Creek upstream of the Robinson Creek confluence.														
Velocity = 1 ft/sec.	Channel Width (wetted edge) in meters (Sept-24-2002)													
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3
Depth (cm)	1	2	5	7	11	14	16	8	12	12	11	10	3	0

Table 4. Channel measurements on Robinson Creek upstream of the Jim Bob Creek confluence.														
Velocity = 2 ft/sec.	Channel Width (wetted edge) in meters (Sept-24-2002)													
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.35
Depth (cm)	0	1	1	8	4	12	12	11	13	5	9	8	2	1

Above the diversion Jim Bob Creek flowed approximately 0.3 cfs (135 gpm). Flows in Jim Bob Creek were measured to be approximately 1.19 cfs near its confluence with Robinson Creek. Water flows in Robinson Creek were measured to be 1.85 cfs just upstream of the Jim Bob Creek confluence. The water diversion removes just under 13.1% of the flow from Jim Bob Creek. Potential flow impacts on Robinson Creek were calculated to be about 5.6%. BLM temperature data indicate that Jim Bob Creek is a cold stream with average temperatures less than 12^{O}C in most years. Water was about 1 ^{O}C below the diversion structure than above the structure. The colder temperatures are likely related to a ground water inflow to Jim Bob Creek downstream of the diversion. Extensive livestock use of riparian vegetation was noted all along Jim Bob Creek to a fence located just above the confluence with Robinson Creek. Modeling change in temperature due to reduced streamflows suggest that Jim Bob Creek would only increase temperature in Robinson Creek by less than 1^{O}C if the water diversion ceased (USDA Forest Service, SSTEMP model). Because Jim Bob Creek is colder downstream of the diversion, this increase is mostly offset by the effect of the diversion removing warmer surface waters resulting in colder than natural inflows to Robinson Creek.

Temperature data and collected in Jim Bob Creek suggests that it could potentially support spawning and early rearing of bull trout. Nevada Division of Wildlife (NDOW, personal communication) indicated that the gradient is too steep in Jim Bob Creek for bull trout other than the lowest segment. Watson and Hillman (1997) reported that stream gradient, stream width, and flow were not useful in determining whether or not bull trout could be present over the range of bull trout in the Pacific Northwest. However, in the Boise River Basin Dunham and Rieman (1999) reported bull trout used areas in streams at least 2 meters wide. Neither NDOW nor the FWS have documented bull trout in Robinson Creek to date, however, redband trout are present. NDOW data indicate there are at least 4 natural obstacles to bull trout movement in Robinson Creek. NDOW commented that during certain times (during low flows) of the year these obstacles potentially form physical barriers to upstream bull trout movements. However, NDOW noted that because redband trout are present above the obstacles, bull trout could possibly negotiate these obstacles earlier in the year when flows are higher.

EF Jarbidge and Dave Creek Tributary Assessment

Seronko and Napkora (2001) conducted an investigation into the watershed impacts related to grazing in the Wilkens Island - Dave Creek area of the Jarbidge Field Office. They first examined the area starting at the head of the main drainage of what is called Wilkens Island (See Figure 1). The drainage is an ephemeral system with associated seep and spring areas along it. The associated ecological sites consists of mainly Clayey 12-15" (alkali sagebrush/Idaho fescue) on the tablelands and side slopes and a mixed Loamy Upland 12-16" (basin big sagebrush/Idaho fescue) Loamy Bottom 12-16" (basin big sagebrush/basin wild rye) along the drainages. The drainages themselves are differing riparian/semi-wet meadow sites. The upland areas also have scattered Aspen Thicket 16-22". During the investigation they walked the entire course of the main drainage that leads into Dave Creek. Findings were documented by means of digital photographs. They observed highly disturbed ecological systems along the entire length of the drainage with the disturbance grading up into the associated uplands in many places.. Many areas were severely lacking vegetative cover due to current grazing practices. Where vegetation is still present it is highly altered by these same practices along with areas of moderate to severe channel damage due to livestock trampling . In areas where willows still exist they are severely grazed. And other shrub species are showing varying stages of mortality. The overall condition of the drainage is very poor and it is a likely source of sediment into Dave Creek and subsequently the East Fork Jarbidge River system during high runoff events.

During the course of this investigation some of the associated aspen stands were walked through. Evidence of severe grazing impacts to these systems were noted in the form of mechanical disturbance to the soil by livestock trampling, heavy utilization on the existing vegetation, vegetative species displacement, and an extremely high amount of livestock feces.

The main drainage that parallels the road leading up out of Murphy Hot Springs and onto Wilkins Island, tributary to the EF Jarbidge River, was next investigated. The main feature noted here was the active head cut at the top of the drainage. The road is an obvious source of some of this disturbance but livestock are a major contributor to this problem. This is evidenced by the occurrence of livestock trampling damage along the upper reaches of this drainage. This drainage contributes sediment directly into the East Fork Jarbidge River and is a potential significant source during high runoff events and as the head cut accelerates.

Conclusions: The current grazing system is having a very negative impact on the drainage systems observed. Mechanical damage to soils and stream banks is evident along major portions of these systems. The vegetative community has been severely altered along the entire reach of the Wilkins Island drainage system. It appears that the use of these drainages for livestock drives at the same time livestock have grazed the area is over taxing the system. The current conditions are a definite source of accelerated erosion and subsequent sediment delivery to the East Fork Jarbidge River. It is recommended that no livestock trail down these areas for at least the next five years for recovery and then a system is developed to move the livestock through the area as quickly as possible with some form of rest or deferment built into the current grazing system for the area. The head cut that was observed along the road up to Wilkins Island may need some form of structural stability and vegetative plantings for long-term stabilization. Fencing to exclude livestock from entering it may also be warranted. Livestock should not be allowed to utilize this drainage until complete stabilization.

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